



# GREEN BANK TELESCOPE



1  
00:00:09,799 --> 00:00:07,730  
first let me say thank you to the

2  
00:00:11,720 --> 00:00:09,809  
organizers for letting me give this talk

3  
00:00:13,430 --> 00:00:11,730  
this is something we actually had this

4  
00:00:15,020 --> 00:00:13,440  
data a tabbed rad-con last year but I

5  
00:00:16,640 --> 00:00:15,030  
couldn't present because we just gotten

6  
00:00:18,800 --> 00:00:16,650  
it and so I sat on my hands for the

7  
00:00:20,269 --> 00:00:18,810  
whole conference so I'm actually really

8  
00:00:22,759 --> 00:00:20,279  
happy to tell you about this because I

9  
00:00:25,160 --> 00:00:22,769  
think you guys will really like it so

10  
00:00:27,050 --> 00:00:25,170  
before I really start there a bunch of

11  
00:00:28,759 --> 00:00:27,060  
people I have to say really helped out

12  
00:00:30,290 --> 00:00:28,769  
with this including our session chair

13  
00:00:33,410 --> 00:00:30,300

Brett this wouldn't have been possible

14

00:00:35,600 --> 00:00:33,420

without the work of a lot of people so

15

00:00:37,370 --> 00:00:35,610

to talk about discovering molecules in

16

00:00:39,080 --> 00:00:37,380

space first I'd like to take a step back

17

00:00:42,139 --> 00:00:39,090

and think about how chemistry works in

18

00:00:44,420 --> 00:00:42,149

space so we start with a star exploding

19

00:00:46,310 --> 00:00:44,430

this is a hard reset for the chemistry

20

00:00:48,139 --> 00:00:46,320

you get some dust but mostly at a demise

21

00:00:50,779 --> 00:00:48,149

is everything blows it all out into

22

00:00:53,360 --> 00:00:50,789

space eventually it aggregates back into

23

00:00:55,369 --> 00:00:53,370

these big clouds of gas and dust these

24

00:00:58,490 --> 00:00:55,379

condense further to make a star and a

25

00:01:00,889 --> 00:00:58,500

disk around as we heard eventually we

26

00:01:02,540 --> 00:01:00,899

form planets these pick up the rest of

27

00:01:06,289 --> 00:01:02,550

the material and in a couple special

28

00:01:08,450 --> 00:01:06,299

cases you get life yeah so that's sort

29

00:01:09,950 --> 00:01:08,460

of the broad overview so as an astro

30

00:01:11,750 --> 00:01:09,960

chemist what I'm interested in is

31

00:01:13,670 --> 00:01:11,760

looking at the chemistry throughout this

32

00:01:15,620 --> 00:01:13,680

process because from here on the

33

00:01:18,080 --> 00:01:15,630

chemistry is constantly running building

34

00:01:20,359 --> 00:01:18,090

bigger and more complex molecules and so

35

00:01:21,980 --> 00:01:20,369

at each one of these steps the chemical

36

00:01:24,050 --> 00:01:21,990

inventory depends on the step before it

37

00:01:25,640 --> 00:01:24,060

so if you want to think about how you're

38

00:01:26,660 --> 00:01:25,650

going to build life on a planet one of

39

00:01:28,850 --> 00:01:26,670

the things you need to think about is

40

00:01:31,100 --> 00:01:28,860

what gets made throughout this process

41

00:01:32,600 --> 00:01:31,110

what you know what processes are

42

00:01:35,749 --> 00:01:32,610

happening that affect how the chemicals

43

00:01:37,190 --> 00:01:35,759

form and what you start with and in

44

00:01:39,289 --> 00:01:37,200

general we do pretty well with this so

45

00:01:42,590 --> 00:01:39,299

we can find all the basic molecules

46

00:01:44,060 --> 00:01:42,600

aldehydes ketones alcohols like bread

47

00:01:45,620 --> 00:01:44,070

said the bigger they are the harder they

48

00:01:48,139 --> 00:01:45,630

are to detect so we're generally limited

49

00:01:50,300 --> 00:01:48,149

to fairly simple molecules but this can

50

00:01:52,340 --> 00:01:50,310

still tell us quite a bit about what you

51  
00:01:53,929 --> 00:01:52,350  
would expect to start with but one thing

52  
00:01:56,149 --> 00:01:53,939  
we've never actually found is a chiral

53  
00:01:57,830 --> 00:01:56,159  
molecule and that's kind of a big thing

54  
00:02:00,319 --> 00:01:57,840  
because if you want to think about how

55  
00:02:02,120 --> 00:02:00,329  
life works life runs on chiral molecules

56  
00:02:04,340 --> 00:02:02,130  
and if we can't find chiral molecules in

57  
00:02:06,200 --> 00:02:04,350  
space we can't say anything about what

58  
00:02:09,529 --> 00:02:06,210  
prop me when or where they form or what

59  
00:02:11,210 --> 00:02:09,539  
processes may influence how they form so

60  
00:02:12,890 --> 00:02:11,220  
just real quick I'll back up in case

61  
00:02:13,790 --> 00:02:12,900  
just to get everybody on the same page

62  
00:02:16,100 --> 00:02:13,800  
i'm sure most

63  
00:02:17,900 --> 00:02:16,110

you know chirality but chirality comes

64

00:02:19,760 --> 00:02:17,910

from the greek word for hand and your

65

00:02:21,800 --> 00:02:19,770

hands are really good example of this so

66

00:02:23,480 --> 00:02:21,810

chiral things are things where they're

67

00:02:25,580 --> 00:02:23,490

mirror image is not superimposable on

68

00:02:27,740 --> 00:02:25,590

itself it's not geometrically the same

69

00:02:29,690 --> 00:02:27,750

so your hands are mirror images they're

70

00:02:32,000 --> 00:02:29,700

identical but they are not

71

00:02:34,190 --> 00:02:32,010

superimposable on themselves and like

72

00:02:35,660 --> 00:02:34,200

your hands molecules can be chiral too

73

00:02:37,150 --> 00:02:35,670

and no matter how you twist them around

74

00:02:39,140 --> 00:02:37,160

they're not exactly the same

75

00:02:40,790 --> 00:02:39,150

interestingly they have all the same

76

00:02:42,200 --> 00:02:40,800

physical properties they melt in boy

77

00:02:44,570 --> 00:02:42,210

them at the same temperature they have

78

00:02:46,370 --> 00:02:44,580

the same basic spectra but they do

79

00:02:48,500 --> 00:02:46,380

distinguish themselves in one important

80

00:02:50,270 --> 00:02:48,510

way and that's when handed things meet

81

00:02:52,130 --> 00:02:50,280

other handed things so you think about a

82

00:02:54,770 --> 00:02:52,140

handshake and do it the right way it's

83

00:02:56,660 --> 00:02:54,780

fine but two right hands meet it's

84

00:02:58,700 --> 00:02:56,670

awkward and the same thing happens with

85

00:03:01,880 --> 00:02:58,710

molecules so you can think of a chiral

86

00:03:03,830 --> 00:03:01,890

molecule binding to some chiral site one

87

00:03:07,760 --> 00:03:03,840

way works well the other way does not

88

00:03:08,930 --> 00:03:07,770

bind nearly as well and so this is kind

89

00:03:11,540 --> 00:03:08,940

of the trick is you have to actually

90

00:03:14,360 --> 00:03:11,550

have something chiral to distinguish a

91

00:03:16,250 --> 00:03:14,370

chiral thing and the reason we're really

92

00:03:17,900 --> 00:03:16,260

interested in this is this thing called

93

00:03:19,400 --> 00:03:17,910

homo chirality again I'm sure most of

94

00:03:21,560 --> 00:03:19,410

the audience knows what this is but just

95

00:03:23,270 --> 00:03:21,570

to go back over it homo chirality is

96

00:03:25,130 --> 00:03:23,280

this interesting property of biology so

97

00:03:27,080 --> 00:03:25,140

biology runs on chiral molecules and

98

00:03:28,810 --> 00:03:27,090

interestingly it runs on all the same

99

00:03:31,580 --> 00:03:28,820

handedness of chiral molecules

100

00:03:33,590 --> 00:03:31,590

essentially for instance you run on all

101

00:03:35,449 --> 00:03:33,600

left-handed amino acids so you use

102

00:03:37,220 --> 00:03:35,459

entirely left-handed amino acids and

103

00:03:39,229 --> 00:03:37,230

right-handed sugars and this lets you do

104

00:03:42,110 --> 00:03:39,239

a lot of interesting things you can

105

00:03:44,030 --> 00:03:42,120

build things like alpha helixes and the

106

00:03:46,250 --> 00:03:44,040

sort of double helix structure of DNA

107

00:03:48,320 --> 00:03:46,260

it's just not possible to do that unless

108

00:03:51,380 --> 00:03:48,330

you actually use entirely the same

109

00:03:54,170 --> 00:03:51,390

handedness of a molecule and so this

110

00:03:56,180 --> 00:03:54,180

actually is evolutionarily sorry

111

00:03:58,160 --> 00:03:56,190

advantageous act right you can build

112

00:03:59,510 --> 00:03:58,170

these big structures and so it makes

113

00:04:01,670 --> 00:03:59,520

sense that you would evolve to this at

114

00:04:04,220 --> 00:04:01,680

some point you would innovate to be homo

115

00:04:05,870 --> 00:04:04,230

chiral the interesting question is not

116

00:04:08,390 --> 00:04:05,880

whether you evolve to this it's what

117

00:04:10,250 --> 00:04:08,400

handedness you pick like I said all you

118

00:04:11,750 --> 00:04:10,260

know both in an tomers have the same

119

00:04:13,880 --> 00:04:11,760

essential physical properties so when

120

00:04:15,320 --> 00:04:13,890

you're faced with the choice between two

121

00:04:17,930 --> 00:04:15,330

seemingly identical things how do you

122

00:04:19,490 --> 00:04:17,940

pick one and the way I like to think

123

00:04:21,680 --> 00:04:19,500

about it is sort of a three-step process

124

00:04:23,120 --> 00:04:21,690

first you generate some excess of

125

00:04:26,029 --> 00:04:23,130

wanting an t'mer over the other some

126

00:04:27,290 --> 00:04:26,039

small fluctuation in one direction then

127

00:04:29,809 --> 00:04:27,300

you amplify this so

128

00:04:31,070 --> 00:04:29,819

lots of auto catalytic processes where

129

00:04:32,540 --> 00:04:31,080

you could think of once you get a little

130

00:04:34,700 --> 00:04:32,550

bit that catalyze is making more and

131

00:04:36,680 --> 00:04:34,710

more of it and then you template this on

132

00:04:38,390 --> 00:04:36,690

to more interesting structures and run

133

00:04:39,920 --> 00:04:38,400

away with it so really if you want to

134

00:04:41,779 --> 00:04:39,930

know why you picked the handedness you

135

00:04:43,490 --> 00:04:41,789

did you have to think back to what

136

00:04:45,080 --> 00:04:43,500

generates your initial and anthemic

137

00:04:48,200 --> 00:04:45,090

access what drives you in one direction

138

00:04:49,610 --> 00:04:48,210

and people have thought about this quite

139

00:04:51,680 --> 00:04:49,620

a bit i'm sure a lot of people in the

140

00:04:53,270 --> 00:04:51,690

room have thought about this if you're

141

00:04:54,740 --> 00:04:53,280

thinking about sitting here on an early

142

00:04:56,809 --> 00:04:54,750

earth with primordial soup there are

143

00:04:59,119 --> 00:04:56,819

lots of ways you could do this surface

144

00:05:01,790 --> 00:04:59,129

catalysis things like binding to clays

145

00:05:03,709 --> 00:05:01,800

preferentially noise it could be totally

146

00:05:05,029 --> 00:05:03,719

random just a small fluctuation in the

147

00:05:07,430 --> 00:05:05,039

chemistry could bump you in one

148

00:05:08,540 --> 00:05:07,440

direction there are more exotic things

149

00:05:10,610 --> 00:05:08,550

that have been proposed like the

150

00:05:13,249 --> 00:05:10,620

electroweak force it's incredibly weak

151  
00:05:15,439 --> 00:05:13,259  
but operating over a planetary scale for

152  
00:05:16,760 --> 00:05:15,449  
millions of years you could make the

153  
00:05:18,680 --> 00:05:16,770  
argument that it would push you in the

154  
00:05:20,749 --> 00:05:18,690  
right direction and then things like

155  
00:05:22,459 --> 00:05:20,759  
certainly polarized light so like I said

156  
00:05:23,930 --> 00:05:22,469  
handed things distinguished themselves

157  
00:05:25,909 --> 00:05:23,940  
when they see other handed things and

158  
00:05:27,170 --> 00:05:25,919  
Mike can be handed to so certainly

159  
00:05:29,300 --> 00:05:27,180  
polarized light will preferentially

160  
00:05:32,149 --> 00:05:29,310  
destroy or do preferential

161  
00:05:33,890 --> 00:05:32,159  
photochemistry but i'm an astro chemist

162  
00:05:37,640 --> 00:05:33,900  
i'm interested in absolutely none of

163  
00:05:41,360 --> 00:05:37,650

these things so what we're interested in

164

00:05:43,850 --> 00:05:41,370

is the material that actually starts on

165

00:05:47,149 --> 00:05:43,860

that starts out in space and ends up on

166

00:05:49,640 --> 00:05:47,159

the earth and so this is actually kind

167

00:05:50,870 --> 00:05:49,650

of backed up by meteoritic data so if

168

00:05:52,610 --> 00:05:50,880

you look at things like the merchants

169

00:05:55,490 --> 00:05:52,620

and meteorite it's chock full of

170

00:05:57,890 --> 00:05:55,500

interesting molecules for building life

171

00:05:59,240 --> 00:05:57,900

and one of them is amino acids and even

172

00:06:01,640 --> 00:05:59,250

more interestingly if you look at it

173

00:06:03,680 --> 00:06:01,650

there are small excesses in the the

174

00:06:06,050 --> 00:06:03,690

amino acids you see a small excessive

175

00:06:08,209 --> 00:06:06,060

left-handed amino acids in the Murchison

176  
00:06:09,860 --> 00:06:08,219  
meteorite and this is a rock that formed

177  
00:06:12,320 --> 00:06:09,870  
at least four and a half billion years

178  
00:06:14,659 --> 00:06:12,330  
ago when the earth was still a pile of

179  
00:06:16,010 --> 00:06:14,669  
gas and dust so this is these are

180  
00:06:19,480 --> 00:06:16,020  
molecules that were formed in space

181  
00:06:22,490 --> 00:06:19,490  
totally abiotic ly well before you have

182  
00:06:24,709 --> 00:06:22,500  
planets even so or roughly the same time

183  
00:06:26,659 --> 00:06:24,719  
so not only can you make these

184  
00:06:28,790 --> 00:06:26,669  
interesting molecules that then

185  
00:06:30,950 --> 00:06:28,800  
eventually make their way in tact to the

186  
00:06:32,480 --> 00:06:30,960  
earth well before you ever make a planet

187  
00:06:34,339 --> 00:06:32,490  
you can actually start with an excess

188  
00:06:37,010 --> 00:06:34,349

way before that and that can be the bias

189

00:06:38,450 --> 00:06:37,020

that pushes you that way so if you want

190

00:06:40,670 --> 00:06:38,460

to think about what processes make

191

00:06:42,499 --> 00:06:40,680

chiral molecules in space and what might

192

00:06:43,939 --> 00:06:42,509

we put push you in that direction you

193

00:06:45,320 --> 00:06:43,949

have to actually detect a chiral

194

00:06:47,300 --> 00:06:45,330

molecule first this is something that

195

00:06:49,219 --> 00:06:47,310

hasn't actually been done and that's a

196

00:06:51,200 --> 00:06:49,229

real problem because you can't detect a

197

00:06:52,939 --> 00:06:51,210

chiral molecule you can't go out and

198

00:06:55,040 --> 00:06:52,949

look at Astrophysical processes that

199

00:06:56,689 --> 00:06:55,050

might actually be doing this because if

200

00:06:58,129 --> 00:06:56,699

you can figure out what processes push

201  
00:07:00,409 --> 00:06:58,139  
you you know what gives you that little

202  
00:07:02,330 --> 00:07:00,419  
excess you could actually make you can

203  
00:07:04,490 --> 00:07:02,340  
start to think about okay well is that

204  
00:07:06,050 --> 00:07:04,500  
does that happen just for the earth does

205  
00:07:08,090 --> 00:07:06,060  
it look the same if you make life

206  
00:07:11,600 --> 00:07:08,100  
somewhere else however Universal is this

207  
00:07:13,010 --> 00:07:11,610  
and what's going on and so the two ways

208  
00:07:15,320 --> 00:07:13,020  
we're really interested in doing this

209  
00:07:18,110 --> 00:07:15,330  
our first there is this really cool

210  
00:07:19,909 --> 00:07:18,120  
paper somebody showed that carbon 14

211  
00:07:22,339 --> 00:07:19,919  
beta decay gives you spin polarized

212  
00:07:23,719 --> 00:07:22,349  
electrons that are universally one

213  
00:07:26,629 --> 00:07:23,729

handedness and this can preferentially

214

00:07:28,159 --> 00:07:26,639

destroy chiral molecules so if this was

215

00:07:30,950 --> 00:07:28,169

the way it worked you would expect this

216

00:07:33,080 --> 00:07:30,960

to be universal so not only would you

217

00:07:35,810 --> 00:07:33,090

see the you know the same handedness

218

00:07:38,420 --> 00:07:35,820

here on earth and Europa and halfway

219

00:07:40,820 --> 00:07:38,430

across the galaxy it'd just be the same

220

00:07:43,370 --> 00:07:40,830

everywhere the other one is certainly

221

00:07:45,469 --> 00:07:43,380

polarized light so you can get very

222

00:07:48,230 --> 00:07:45,479

strong certainly polarized UV light in a

223

00:07:50,180 --> 00:07:48,240

lot of sources and it changes so from

224

00:07:52,909 --> 00:07:50,190

here in Orion down to the Horsehead

225

00:07:55,129 --> 00:07:52,919

Nebula you see big changes in you go

226

00:07:56,960 --> 00:07:55,139

from linear down to circular sorry

227

00:07:58,279 --> 00:07:56,970

circular down to linearly polarized

228

00:08:00,200 --> 00:07:58,289

light so you can actually go out and

229

00:08:02,390 --> 00:08:00,210

just observe sources figure out what the

230

00:08:05,060 --> 00:08:02,400

circular polarization is and then make

231

00:08:07,100 --> 00:08:05,070

some claim about what you expect the

232

00:08:08,600 --> 00:08:07,110

enantiomeric excess is to start looking

233

00:08:10,399 --> 00:08:08,610

like if you're building molecules in

234

00:08:11,779 --> 00:08:10,409

these places so these are the kinds of

235

00:08:13,879 --> 00:08:11,789

things you could think about testing if

236

00:08:17,240 --> 00:08:13,889

you could actually find chiral molecules

237

00:08:19,850 --> 00:08:17,250

at space so that's that's what we work

238

00:08:21,439 --> 00:08:19,860

on so I'm part of the prime most project

239

00:08:24,350 --> 00:08:21,449

the prebiotic demo interstellar

240

00:08:26,719 --> 00:08:24,360

molecular survey it's a radio survey so

241

00:08:28,540 --> 00:08:26,729

Mike Brett said our best tool for

242

00:08:32,269 --> 00:08:28,550

detecting new molecules in space is

243

00:08:34,640 --> 00:08:32,279

radio astronomy and for reasons that are

244

00:08:38,329 --> 00:08:34,650

not entirely clear Sagittarius be to

245

00:08:40,339 --> 00:08:38,339

North is a small actually fairly large

246

00:08:42,380 --> 00:08:40,349

cloud of gas and dust very close to the

247

00:08:45,590 --> 00:08:42,390

center of our galaxy 20,000 light-years

248

00:08:48,680 --> 00:08:45,600

away and it is the best place to find

249

00:08:50,060 --> 00:08:48,690

new molecules in space so if a complex

250

00:08:51,710 --> 00:08:50,070

molecule has been seen in space it's

251  
00:08:54,020 --> 00:08:51,720  
almost definitely been seen there first

252  
00:08:55,490 --> 00:08:54,030  
and pretty much always seen there

253  
00:08:57,380 --> 00:08:55,500  
so if you want to look for new molecules

254  
00:08:59,270 --> 00:08:57,390  
this is the place to do it so we got

255  
00:09:02,140 --> 00:08:59,280  
interested in this and started thinking

256  
00:09:04,670 --> 00:09:02,150  
about how to detect these molecules so

257  
00:09:06,580 --> 00:09:04,680  
if you want to detect molecules you go

258  
00:09:09,410 --> 00:09:06,590  
for the biggest telescope you can

259  
00:09:10,880 --> 00:09:09,420  
telescopes are like buckets the bigger

260  
00:09:13,160 --> 00:09:10,890  
the telescope the more light you catch

261  
00:09:15,350 --> 00:09:13,170  
so the Green Bank telescope is the

262  
00:09:19,040 --> 00:09:15,360  
world's largest fully steerable radio

263  
00:09:21,050 --> 00:09:19,050

telescope Arecibo beats it but this is

264

00:09:22,880 --> 00:09:21,060

easily the biggest one that can actually

265

00:09:28,010 --> 00:09:22,890

observe Sagittarius for reference this

266

00:09:29,480 --> 00:09:28,020

is the Statue of Liberty it's huge and

267

00:09:30,920 --> 00:09:29,490

so we have this project in with the

268

00:09:33,320 --> 00:09:30,930

Green Bank telescope it's actually so

269

00:09:35,540 --> 00:09:33,330

useful we've just got this huge archive

270

00:09:37,010 --> 00:09:35,550

of data we can mine that's already been

271

00:09:40,760 --> 00:09:37,020

done so we started digging through the

272

00:09:43,460 --> 00:09:40,770

data and we initially got these two hits

273

00:09:45,080 --> 00:09:43,470

so these dips are the rotations of the

274

00:09:46,960 --> 00:09:45,090

end over end rotation of the molecule

275

00:09:49,430 --> 00:09:46,970

absorbing against the background of

276

00:09:51,650 --> 00:09:49,440

Sagittarius and these are just the

277

00:09:53,210 --> 00:09:51,660

quantum numbers but as we dug through

278

00:09:54,950 --> 00:09:53,220

the data we initially got these two hits

279

00:09:57,650 --> 00:09:54,960

and we got really excited because two

280

00:09:59,540 --> 00:09:57,660

hits is a really decent chance that it's

281

00:10:01,400 --> 00:09:59,550

a real molecule and not just something

282

00:10:02,840 --> 00:10:01,410

spurious so we actually have good

283

00:10:05,150 --> 00:10:02,850

statistics we can look at the whole data

284

00:10:06,980 --> 00:10:05,160

set and see what incident how often you

285

00:10:08,630 --> 00:10:06,990

get small absorption features from

286

00:10:12,500 --> 00:10:08,640

something either a molecule we can't

287

00:10:14,390 --> 00:10:12,510

identify or just any instrument response

288

00:10:16,550 --> 00:10:14,400

and so it's about three percent chance

289

00:10:19,640 --> 00:10:16,560

that you have an absorption that would

290

00:10:22,430 --> 00:10:19,650

fall randomly just randomly on this

291

00:10:23,870 --> 00:10:22,440

frequency so for two of them its point

292

00:10:26,750 --> 00:10:23,880

oh nine percent which is actually pretty

293

00:10:28,640 --> 00:10:26,760

good for us we this is a pretty sound

294

00:10:31,190 --> 00:10:28,650

detection but it's not good enough

295

00:10:32,420 --> 00:10:31,200

referees really want to see you do more

296

00:10:34,910 --> 00:10:32,430

because there should be several more

297

00:10:37,240 --> 00:10:34,920

detectable transitions so we went and

298

00:10:41,300 --> 00:10:37,250

looked for the next one in the series so

299

00:10:43,550 --> 00:10:41,310

this is the NOAA this is sort of the RMS

300

00:10:47,740 --> 00:10:43,560

from before and this is what we got this

301  
00:10:49,660 --> 00:10:47,750  
is not signal at all it's DIRECTV

302  
00:10:52,450 --> 00:10:49,670  
yeah so it turns out there is a

303  
00:10:55,000 --> 00:10:52,460  
geosynchronous satellite TV satellite

304  
00:10:56,920 --> 00:10:55,010  
right over North America broadcasting

305  
00:10:59,320 --> 00:10:56,930  
right at this frequency so it keeps

306  
00:11:00,400 --> 00:10:59,330  
going a little bit but there is when

307  
00:11:02,320 --> 00:11:00,410  
you're looking for really weak

308  
00:11:03,910 --> 00:11:02,330  
absorption features from 20,000

309  
00:11:05,590 --> 00:11:03,920  
light-years away from you this is

310  
00:11:08,250 --> 00:11:05,600  
unacceptable you just can't do anything

311  
00:11:10,990 --> 00:11:08,260  
with it so the solution was to go to

312  
00:11:13,390 --> 00:11:11,000  
parks in Australia they don't have a

313  
00:11:14,710 --> 00:11:13,400

timeless they don't have any sorry

314

00:11:16,990 --> 00:11:14,720

satellites broadcasting at that

315

00:11:19,450 --> 00:11:17,000

frequency and their telescopes not quite

316

00:11:22,350 --> 00:11:19,460

as big but it's 60 meters instead of 100

317

00:11:25,120 --> 00:11:22,360

and it's pretty phenomenal for this and

318

00:11:27,580 --> 00:11:25,130

so we integrated took us most of the

319

00:11:29,500 --> 00:11:27,590

week and we got a hit so this is the

320

00:11:31,630 --> 00:11:29,510

last absorption feature we were looking

321

00:11:34,240 --> 00:11:31,640

for so now we can put it together with

322

00:11:36,610 --> 00:11:34,250

the other two and now the odds that all

323

00:11:38,980 --> 00:11:36,620

three of these coincidentally line up

324

00:11:42,340 --> 00:11:38,990

with the transition frequencies for this

325

00:11:44,500 --> 00:11:42,350

molecule are pretty much null so this is

326

00:11:46,960 --> 00:11:44,510

it we've got all three hits for a chiral

327

00:11:48,370 --> 00:11:46,970

molecule and actually we can do a little

328

00:11:50,230 --> 00:11:48,380

bit better than this the statistics were

329

00:11:51,580 --> 00:11:50,240

for this region I astley what's how

330

00:11:54,340 --> 00:11:51,590

likely is that they fall within that

331

00:11:55,900 --> 00:11:54,350

window but they all match up basically

332

00:11:59,380 --> 00:11:55,910

perfectly so if you ask what are the

333

00:12:02,110 --> 00:11:59,390

odds that you get all three hits within

334

00:12:04,510 --> 00:12:02,120

that window it's about one in a billion

335

00:12:06,700 --> 00:12:04,520

it's pretty low and we can also use this

336

00:12:09,220 --> 00:12:06,710

to derive the temperature so the gas is

337

00:12:11,500 --> 00:12:09,230

extremely cold it's about five Kelvin

338

00:12:13,090 --> 00:12:11,510

and so now we can put this together this

339

00:12:14,860 --> 00:12:13,100

molecule this is the molecule propylene

340

00:12:17,620 --> 00:12:14,870

oxide so we've got three absorption

341

00:12:19,810 --> 00:12:17,630

transitions from it we also detect two

342

00:12:21,340 --> 00:12:19,820

structural isomers so I am a chemist I

343

00:12:22,840 --> 00:12:21,350

do like to start thinking about how not

344

00:12:25,329 --> 00:12:22,850

just finding these things but how they

345

00:12:27,520 --> 00:12:25,339

fit in the bigger chemical picture so

346

00:12:29,920 --> 00:12:27,530

acetone and for panel or structural

347

00:12:32,920 --> 00:12:29,930

isomers and we put them together we also

348

00:12:37,450 --> 00:12:32,930

found simpler epoques side so this has

349

00:12:40,540 --> 00:12:37,460

the nice parkside ring but anyway we

350

00:12:41,650 --> 00:12:40,550

have 21 to six to one ratio so this is

351

00:12:43,690 --> 00:12:41,660

telling us this is way out of

352

00:12:46,060 --> 00:12:43,700

thermodynamic equilibrium it's exactly

353

00:12:47,650 --> 00:12:46,070

what you expect but I need to hurry up

354

00:12:49,390 --> 00:12:47,660

and finish I'll skip the rest of this

355

00:12:52,390 --> 00:12:49,400

and just say these ratios look really

356

00:12:53,920 --> 00:12:52,400

close to what we see in comets and

357

00:12:55,300 --> 00:12:53,930

that's really cool it says that this

358

00:12:56,710 --> 00:12:55,310

might be happening it this is the

359

00:12:59,050 --> 00:12:56,720

chemistry mine be seen in the solar

360

00:13:01,449 --> 00:12:59,060

system too so I'll just wrap it up and

361

00:13:03,460 --> 00:13:01,459

say we detected mom

362

00:13:05,319 --> 00:13:03,470

you'll it's Cairo let's propylene oxide

363

00:13:14,679 --> 00:13:05,329

and we've got a lot of work to do now to

364

00:13:16,629 --> 00:13:14,689

figure out what this means no thanks we

365

00:13:20,379 --> 00:13:16,639

have time for questions Bradley were you

366

00:13:23,470 --> 00:13:20,389

saving a question okay sorry he got in

367

00:13:24,939 --> 00:13:23,480

way early on the question train and you

368

00:13:26,949 --> 00:13:24,949

have to use the microphone because we

369

00:13:31,269 --> 00:13:26,959

have a screen going live on sega net so

370

00:13:32,439 --> 00:13:31,279

please wait for the microphone so what

371

00:13:36,220 --> 00:13:32,449

do you have to do to figure out if

372

00:13:37,960 --> 00:13:36,230

there's a chiral excess there so there's

373

00:13:39,819 --> 00:13:37,970

mAb work to calibrate it and then

374

00:13:42,730 --> 00:13:39,829

there's really sensitive so basically

375

00:13:43,840 --> 00:13:42,740

you do circular dichroism so you put you

376

00:13:45,759 --> 00:13:43,850

measure the amount of circularly

377

00:13:47,919 --> 00:13:45,769

polarized light that's absorbed and if

378

00:13:50,139 --> 00:13:47,929

you see in excess and one handedness but

379

00:13:52,960 --> 00:13:50,149

that is super hard at radio frequencies

380

00:13:55,660 --> 00:13:52,970

with a telescope for so many reasons

381

00:13:58,150 --> 00:13:55,670

this is a matter of time or technology

382

00:14:00,069 --> 00:13:58,160

the technology feasibly exists it's

383

00:14:02,019 --> 00:14:00,079

probably a matter of time calibrating a

384

00:14:06,489 --> 00:14:02,029

telescope to do this to the precision

385

00:14:11,889 --> 00:14:06,499

you need is incredibly difficult cool

386

00:14:13,629 --> 00:14:11,899

thank you you stole this question I'm

387

00:14:18,039 --> 00:14:13,639

sorry all right we got another one down

388

00:14:20,289 --> 00:14:18,049

here it's a fair question thank you that

389

00:14:22,059 --> 00:14:20,299

was an Austin talk um you mentioned at

390

00:14:23,980 --> 00:14:22,069

one point supernova kind of reset the

391

00:14:25,419 --> 00:14:23,990

chemistry but then talked about in the

392

00:14:26,769 --> 00:14:25,429

merchants of meteorite from the

393

00:14:28,389 --> 00:14:26,779

formation of the solar system that was

394

00:14:30,340 --> 00:14:28,399

already pretty complex things going on

395

00:14:31,689 --> 00:14:30,350

yeah what's the how do we reconcile that

396

00:14:33,429 --> 00:14:31,699

like what's how long do we expect that

397

00:14:35,799 --> 00:14:33,439

to take millions and millions of years

398

00:14:38,319 --> 00:14:35,809

so that's what happens is basically

399

00:14:40,449 --> 00:14:38,329

supernova explodes that gasps flies out

400

00:14:42,069 --> 00:14:40,459

very far away and eventually gravity

401  
00:14:43,780 --> 00:14:42,079  
takes over again it will coalesce and

402  
00:14:45,970 --> 00:14:43,790  
then you have millions of years of

403  
00:14:47,980 --> 00:14:45,980  
condensation and like Brett said and

404  
00:14:50,169 --> 00:14:47,990  
like gas and grain surface chemistry

405  
00:14:52,239 --> 00:14:50,179  
just constantly runs and smoothly pieces

406  
00:14:53,980 --> 00:14:52,249  
it back together and then eventually it

407  
00:14:56,829 --> 00:14:53,990  
aggregates into a solar system and

408  
00:14:58,449 --> 00:14:56,839  
meteorites so along the way you start

409  
00:15:00,189 --> 00:14:58,459  
building up to things like amino acids

410  
00:15:01,749 --> 00:15:00,199  
right but they're already pretty much

411  
00:15:04,299 --> 00:15:01,759  
going on before solar system formation

412  
00:15:05,739 --> 00:15:04,309  
then yeah or there could be I mean

413  
00:15:07,720 --> 00:15:05,749

chemistry still running as the solar

414

00:15:10,509 --> 00:15:07,730

system forms it's not one it doesn't

415

00:15:12,429 --> 00:15:10,519

stop so yeah this but yeah they should

416

00:15:14,289 --> 00:15:12,439

be built before that we're working so

417

00:15:15,369 --> 00:15:14,299

we've tried to detect glycine repeatedly

418

00:15:17,979 --> 00:15:15,379

this is like one of

419

00:15:20,199 --> 00:15:17,989

it's like astrochemistry is one of its

420

00:15:21,909 --> 00:15:20,209

big goals and one of its constant

421

00:15:25,739 --> 00:15:21,919

stumbling blocks we can't detect glycine

422

00:15:27,759 --> 00:15:25,749

yet but we're working on it thank you